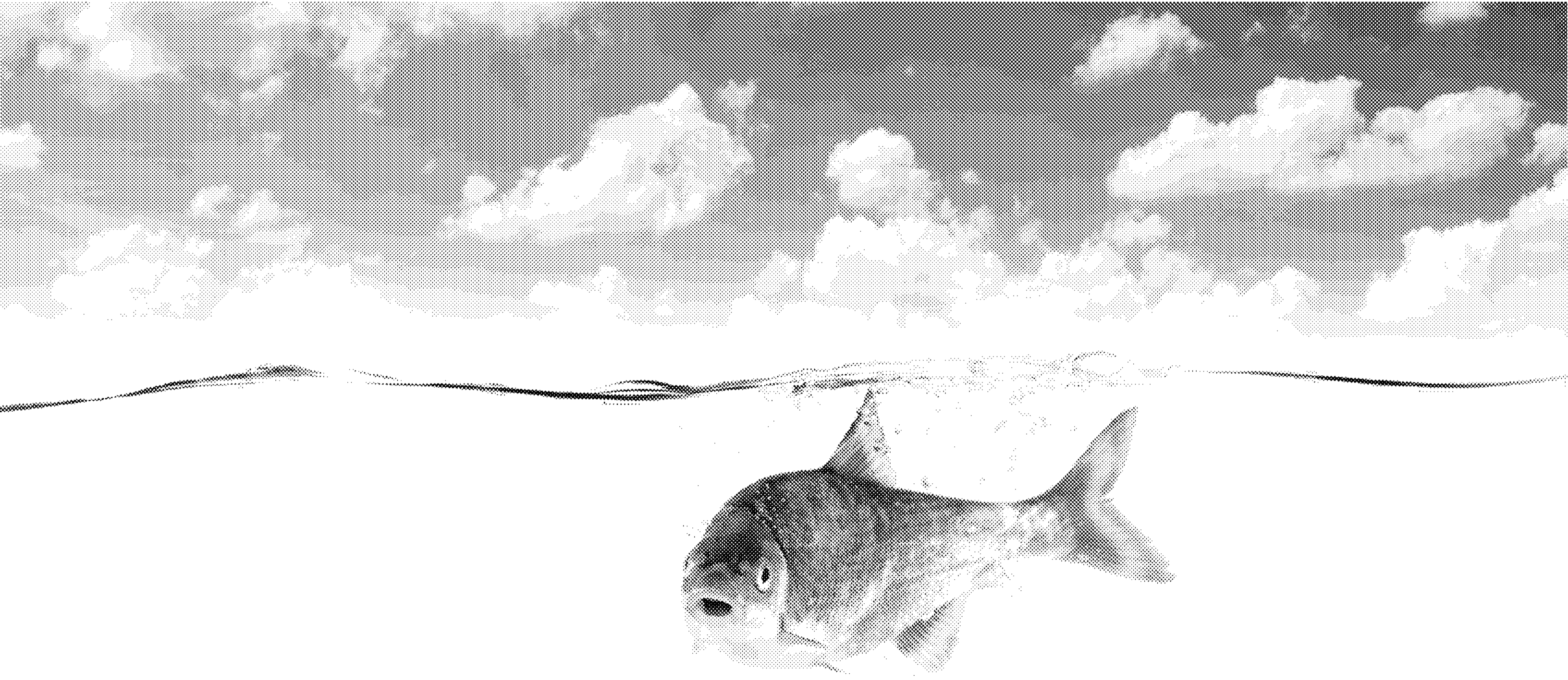

Standard Operating Procedure

Quality Assurance and Quality Control

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1.1 General Overview

The quality assurance plan includes a number of formal components and procedures outlined below that will be implemented to evaluate the quality and integrity of data produced by the 2018 to 2020 Koocanusa Reservoir monitoring program. Additional useful guidance can be found in the BC Field Sampling Manual (Province of BC 2013) and federal EEM guidance (Environment Canada 2012a).

1.2 Study Team Responsibilities and Training

1.2.1 Technical

Study personnel must be appropriately educated, trained, and experienced for their respective technical responsibilities, whether in the field, laboratory, or office. Study personnel may be required by Teck to provide proof of education level or professional qualifications (e.g., Registered Professional Biologist). Project personnel must be familiar with study design requirements and methods relevant to their project role.

There are no formal training/certification programs for the types of sampling that will be completed for the 2008 to 2020 Koocanusa Reservoir monitoring program. Therefore, training for the components of the Koocanusa Reservoir surveys will be the joint responsibility of Teck and its consultants. Teck will review the qualifications and experience of project personnel relative to their assigned responsibilities in advance of field programs. Field crews will have read and become familiarized with the BC Field Sampling Manual requirements and sampling procedures (Province of BC 2013).

1.2.2 Health and Safety

Safety is of primary importance. Members of the project team are expected to contribute toward healthy and safe work conditions by being familiar with and complying with applicable Health and Safety Procedures. Environment, Health, Safety, and Community (EHSC) work plans and Environmental Protection Work Plans (EPWPs) must be filed with Teck in advance of field work taking place at or near Teck's mining operations. In addition, a field level hazard assessment (FLHA) is expected to be completed daily prior to starting work. Proper training regarding potential work-related hazards is also important.

Prior to execution of field work, field personnel should also receive training/certification, as applicable, through a qualified organization for activities such as:

- First aid and Cardiopulmonary Resuscitation (CPR);

- Workplace Hazardous Materials Information System (WHMIS);
- Transport of Dangerous Goods
- Boat operation (i.e., pleasure craft operators certification);
- Swift water rescue;
- Ice rescue; and
- Bear awareness.

1.3 Consistency (Standard Operating Procedures)

Consistency is an important component of a quality management program. To minimize errors and to maintain comparability of data over time, standard operating procedures (SOPs) must be followed for sample collection methods, calibration, and maintenance of field instruments, and proper sample handling and laboratory sample submission procedures. Each SOP should describe, in detail, the routine procedures to be followed. Short-term deviations from specified methods that occur should be documented in field notes and conveyed as appropriate in the technical reports in which the data are presented

1.4 Data Quality Assurance and Quality Control

1.4.1 Definition of Terms

1.4.1.1 General

Although the general intent and process for data quality assurance has become increasingly standardized, the terminology and definitions used in controlling and describing the quality of environmental data varies among geographical locations, regulatory agencies, accreditation bodies, and practitioners. For the purpose of the monitoring conducted under the Koocanusa Reservoir monitoring program, the terminology and processes relating to data quality are defined below.

Quality Assurance (QA) is a set of operating principles that, if strictly followed, will produce data with a quality that is defined and satisfies the intended use of the data. Included in QA is quality control (QC). QC involves special actions taken to measure and control data errors and variability associated with sampling, analysis, and reporting such that the resulting data are sufficiently accurate and precise to serve the purpose(s) for which they are collected. Ideally, performance elements will be controlled such that the variability observed in the data can be assumed to reflect real spatial or temporal variability. QC in an environmental monitoring program typically includes such elements as laboratory method detection limits (MDLs) for chemical analyses, as well as requirements for collection and analysis of field and laboratory replicate samples, field and laboratory blank sample analysis, laboratory recovery of known chemical additions to samples (spike recoveries), and analysis of standard reference materials, etc. (described below).

Data quality objectives (DQOs) represent the performance expectations for QC elements and serve as criteria for data acceptability. DQOs should be developed for new projects in advance of sample collection and analysis, and the performance expectations should be established based on consideration of how the data will be used (i.e., what questions will the data be used to answer) as well as the technical feasibility of collecting data of such quality. Guidance for establishing DQOs has been developed by the USEPA (2006).

Data quality assessment (DQA) is the process of comparing actual field and laboratory performance to the DQOs to determine the overall quality of the data. The goal of data quality assessment is to identify significant issues with the data (e.g., performance outside of accepted boundaries) and to take action in a timely and efficient manner to address errors and concerns. This process will help confirm that the data are associated with a defined level of quality and thus enhance the defensibility of the data in the context of their ultimate use.

Assurance of adequate data quality is possible only when specific data uses and DQOs have been defined. Analytical DQOs may pertain to factors such as sensitivity, precision, accuracy, comparability, compatibility, representativeness, and completeness.

QC samples are collected in the field and in the laboratory. General guidelines for the type of QC samples required to track and minimize the effects of bias and imprecision in the sampling effort are outlined below. The number of QC samples should correspond to a minimum of 10% of the total number of samples taken in the sampling period the QC samples are intended to represent. QC samples are integral to a QA program, and recommendations for their use should be strictly adhered to.

The QA plan for Koocanusa Reservoir monitoring plan includes a number of formal components and procedures, explained below, that will be used to assure the quality and integrity of data.

1.4.1.2 QC Indicators

Sensitivity describes the lowest concentration, or increment of concentration, that a laboratory technique is able to detect or quantitate with a certain level of confidence, which can be defined in different ways (e.g., see below). This limit must be less than the environmental quality guidelines to which the data will be compared and preferably 1/10th that value or lower since analytical precision is reduced at concentrations approaching the method detection limit (McQuaker 1999).

- **Laboratory reporting limit (LRL)**: The lowest concentration of an analyte reported within a reasonable degree of accuracy and precision, ideally synonymous with the lower limit of quantitation (LLOQ). The LRL is typically 3-10 times the MDL, but some guidelines are so low that the LRL is equal to the MDL in order to report to the guideline.

- **LLOQ** is the lowest concentration of an analyte that can be reliably measured within specified limits of precision and accuracy during routine operating conditions, as opposed to being detected which, in most cases, is the lowest concentration on the calibration curve.
- **MDL** usually refers to the minimum concentration of an analyte that can be measured and reported with 99% confidence to be greater than zero for a given matrix and specific method.

Precision refers to the degree of agreement between or among repeated measurements of the same characteristic. It may be determined by calculating the relative percent difference (for duplicate values) or relative standard deviation (for replicates of more than two), for field or laboratory samples.

Accuracy refers to how closely a result corresponds with the true or expected value and is often determined by comparing the value measured in a standard or reference sample to the certified (actual) value. QC analyses used to measure accuracy include standard recoveries, laboratory control samples, spiked blank samples, and spiked environmental samples.

Bias refers to the degree to which there is a systematic error in one direction from a true value (% Bias = % Recovery – 100 or % Bias = $(C - C_{standard})/C_{standard}$). Bias is not required to be assessed within the Regional Aquatic Effects Monitoring Plan (RAEMP) if targets for data accuracy are being met for analytes of interest. However, bias should be evaluated if accuracy targets are not met and/or a pattern of potential bias is noted during the review of accuracy data.

1.4.1.3 QC Sample Types

Certified reference materials are samples containing known chemical concentrations that are processed and analyzed by an analytical laboratory along with batches of environmental samples. The sample results are then compared to the known (e.g., certified) amount to provide a measure of analytical accuracy. The results are reported as the percent of the known amount that was recovered in the analysis.

Internal (or QC) standards may be spiked into prepared field samples and QC samples (or sample extracts) by the laboratory for calibration and controlling the precision and bias of the applied analytical method. Their recovery is generally used to account for matrix effects and/or variability in instrument response by normalizing the response of the target analytes and surrogates.

Laboratory replicate samples (typically duplicates) are sub-samples taken by the laboratory from the same sample container and prepared and analyzed in the same way. The results from replicate analyses are used to evaluate analytical or measurement precision.

Matrix spikes are aliquots of environmental samples to which known concentrations of certain target analytes have been added by the laboratory before sample preparation and determinative procedures have been implemented. The matrix spike analysis is used to assess the potential effects of matrix interferences on the accuracy (and potentially also bias) of the method by measuring the percent recovery of the known spike amount.

Method blanks are prepared and analyzed by the laboratory to assess background interference or contamination that exists in the analytical system that might lead to the reporting of elevated concentration levels or false positive data. The method blank is an analyte-free sample to which reagents are added in the same volumes or proportions as used in sample preparation and carried through the complete sample preparation, cleanup, and determinative procedures. The method blank results should be below the LLOQ for the target analytes being tested.

Organism sub-sampling accuracy refers to how closely the total sample abundance estimated by a laboratory based on counting organisms in a sub-sample (e.g., benthic invertebrates) reflects the total number of organisms actually present in the sample. To do this, the laboratory typically analyses a subset of samples in their entirety, while in the process also keeping track of organism counts for all sub-samples comprising the total sample. Then the % error is calculated for each subsample as:

> (([estimated total sample abundance based on processing of subsample] – [estimated total sample abundance based on processing of entire sample]) / (estimated total sample abundance based on processing of entire sample)) X 100.

If a sample is so large that it would be excessively time consuming to process the entire sample, then the same calculation is performed relative to the total sample abundance estimated from multiple sub-sample counts.

Organism sub-sampling precision refers the degree of agreement between sub-sample organism counts in laboratory processing of biological community samples (e.g., benthic invertebrates, plankton). The % error is calculated by computing the relative percent difference for pairs of sub-samples, as follows:

> ([organism abundance in sub-sample A]-[organisms abundance in sub-sample B] / [mean subsample abundance]) x 100

The Canadian Aquatic Biomonitoring Network (CABIN) laboratory sample processing protocol stipulates that sufficient sub-samples must be collected to total at least 300 organisms

(Environment Canada 2012b). For both phytoplankton, zooplankton community samples, and fish aging (otoliths) sub-sampling accuracy will be assessed by performing replicate counts on 10% of samples (in this case, one sample each year). Replicate samples will be chosen at random and processed at different times from the original sample to reduce bias.

Organism recovery (or sorting recovery or efficiency) refers to laboratory processing of biological community samples (typically benthic invertebrates) to determine if organisms were missed in the original processing of the sample. Typically, this involves a second analyst spot-checking the leftover sample debris after the first analyst has completed extraction of organisms.

1.4.2 Field QA/QC

Data quality begins with use of appropriate sampling equipment and instruments, adherence to SOPs for taking measurements or samples in the field, and appropriate and accurate documentation of relevant field information and observations.

Field instruments must be regularly calibrated, maintained, and operated in accordance with the manufacturer's instructions. Containers used for samples for chemical analyses should be kept closed, in a clean environment, away from dust, dirt, and fumes. Chemistry samples should never be permitted to get warm (and in the case of water or sediment samples should not freeze) and must be shipped to the laboratory promptly to meet holding time limits. Field sheets should be prepared in advance of the program and include prompts for documentation of the sampling location (Global Positioning System [GPS] coordinates), relevant field conditions/measurements, samples taken, extra QC samples collected, and photographs taken. Field sheets must be signed and dated.

Chain-of-custody (COC) forms must also be filled out to achieve traceability of samples from the field to the laboratory.

1.4.3 Laboratory Data QA-QC

DQOs for Koocanusa Reservoir monitoring have been established for different QC indicators applicable to the RAEMP (Table 1.1).

Chemical analysis of samples should be performed by a laboratory that has achieved accreditation for the relevant analyses through the Canadian Analytical Laboratory Association (CALA). Potential exceptions may include highly specialized, non-routine analyses for which formal certification is not currently available; however, in such cases, the QA/QC practices that will be followed and reported by the laboratory must be established in advance and conform to the general data quality control requirements established for the Koocanusa Reservoir monitoring program, as outlined in the next section.

In addition to the QA/QC requirements specified above, the following requirements will apply:

- Laboratories will be instructed to retain samples until data are reported and the quality of data is assessed relative to DQOs listed in Table 1.1
- Field sheets, sorted invertebrate samples, and fish age structures must be archived at least until the study report has been completed and undergone external technical review.

1.5 Data Quality Assessment, Data Management Responses, and Reporting

The overall objective of a quality assurance program is to control errors to the degree possible to maximize their quality, usefulness, and reliability. Data quality assessment (DQA) involves the process of evaluating how well DQOs and other QC requirements were met. The DQA will be performed before the data are analyzed and interpreted relative to the study objectives. The assessment will be based on a direct comparison of QC sample results with the objectives specified in Table 1.1 for each sample type. Relevant data will be presented in the final interpretive project report. Observations that may affect the reliability of the collected data with respect to serving the project objectives must be clearly identified.

Table 1.[SEQ Table * ARABIC \s 1]: **Data Quality Objectives for Aquatic Ecological**

Quality Control Measure	Quality Control Sample Type/Check	Study Component			
		Tissue Quality	**Plankton Community**	**Benthic Invertebrate Community**	**Fish Morphometrics**
Analytical Laboratory Reporting Limits (LRL)	Comparison actual LRL versus target LRL	LRL for each parameter should be at least as low as applicable guidelines, ideally ≤1/10th guideline value[a]	n/a	n/a	n/a
Laboratory Precision	Laboratory Replicates	≤30% RPD or RSD[b]	n/a	n/a	n/a
	Organism Sub-Sampling Precision	n/a	n/a	≤20% difference between sub-samples; minimum of 5% of each sample must be analyzed	n/a
Accuracy	Recovery of Blank Spike	75-125%	n/a	n/a	n/a
	Recovery Matrix Spike	75-125%	n/a	n/a	n/a
	Recovery of Certified Reference Material, QC Standards	70-130%	n/a	n/a	n/a
	Organism Recovery	n/a	n/a	minimum 90% recovery	n/a
	Organism Sub-Sampling Accuracy	n/a	replicate counts on 10% of samples	80-120%	n/a
	Instrument Accuracy	n/a	n/a	n/a	use instruments that provide measurement accuracy of ≤10% for weight (whole organism or tissue) and length

Samples

[LINK Excel.Sheet.12 "\\\\10.72.4.2\\Data\\Projects\\187202\\187202.0007 - Teck Koocanusa 2018\\SOP stuff\\Table 1.1 DQOs for Samples.xlsx" "T 4.1!R3C1:R13C6" \a \f 4 \h * MERGEFORMAT]

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